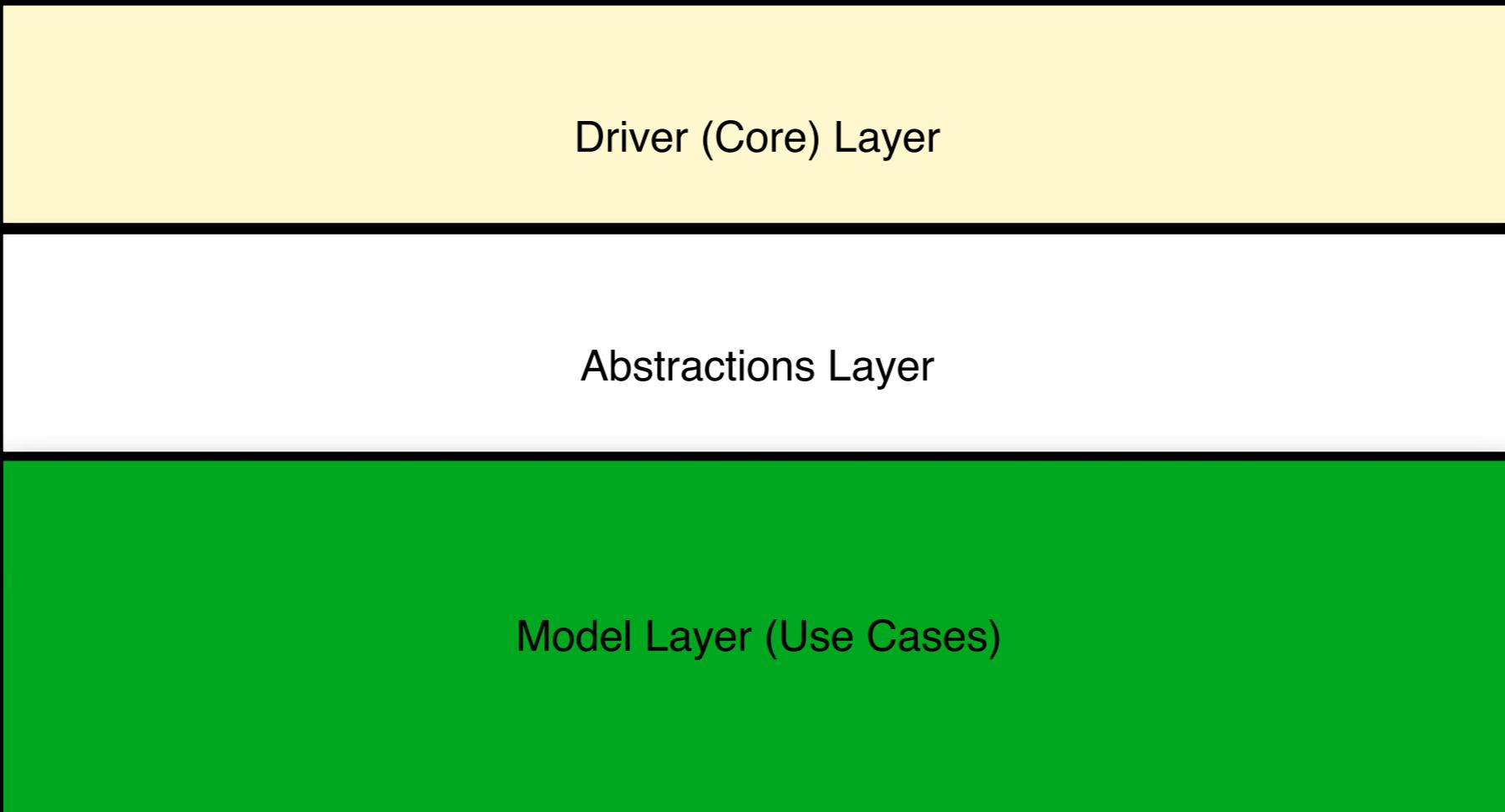




# Land Information System

## Version 6.0



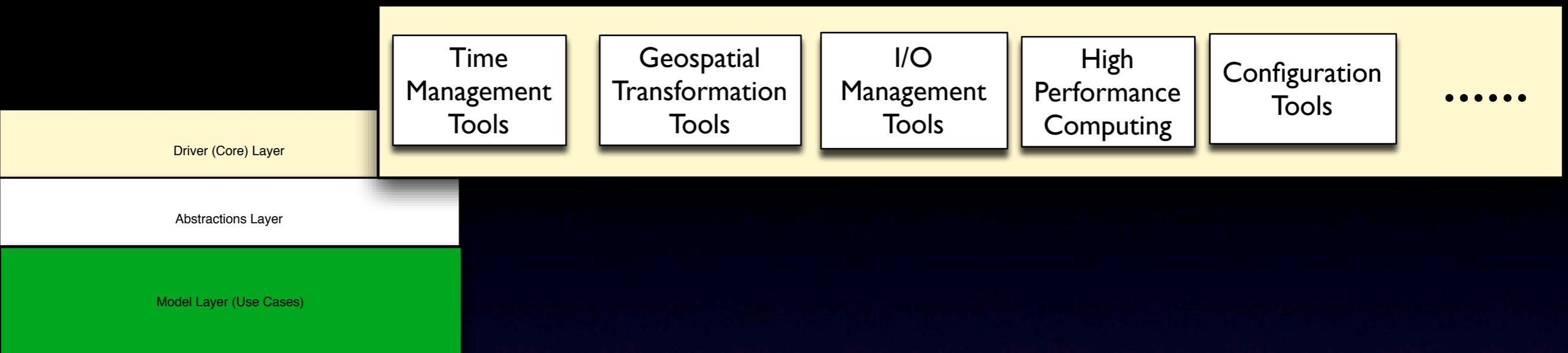
# LIS software architecture

Driver (Core) Layer

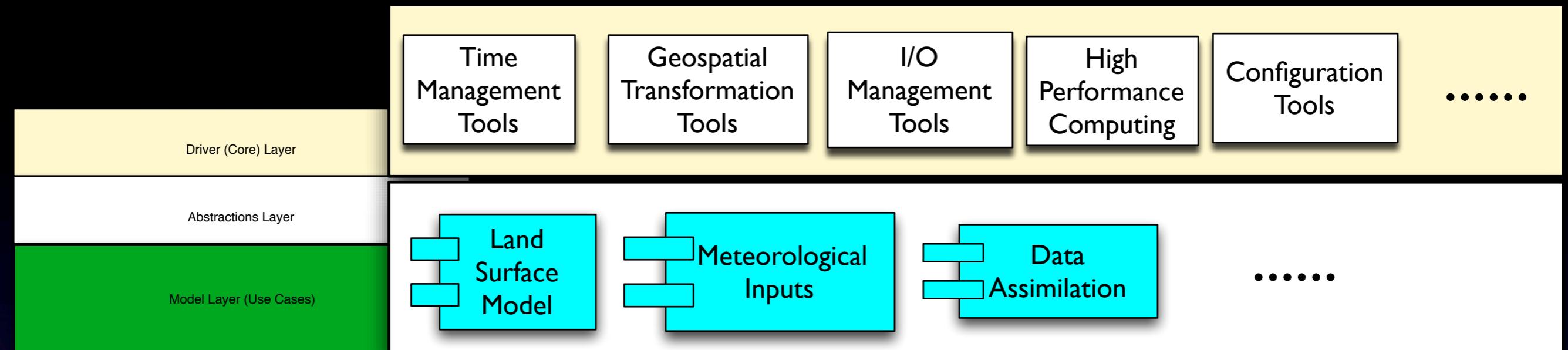
Abstractions Layer

Model Layer (Use Cases)

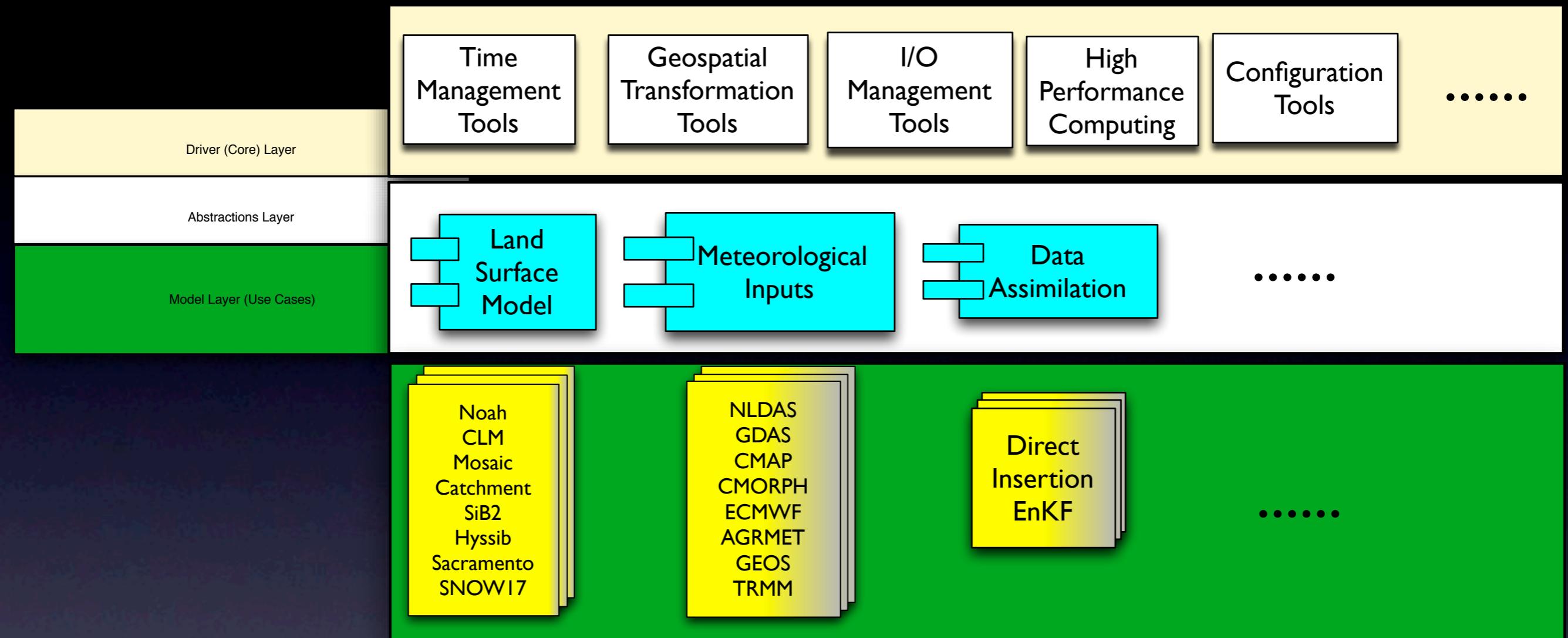
# LIS software architecture



# LIS software architecture



# LIS software architecture



# LIS software architecture

# Core Layer Enhancements

Introducing the latest enhancements to our core layer, designed to provide you with a more reliable and efficient network experience.

The new features include improved routing algorithms, enhanced security measures, and increased bandwidth capacity, all delivered through a simplified management interface.

With these enhancements, we are confident that our core layer will continue to meet the needs of our customers and provide a stable foundation for their networks.

To learn more about the latest Core Layer Enhancements, please contact our support team or visit our website.

We look forward to your feedback and continued success with our products and services.



# Uses ESMF3 series

Uses ESMF3 series

Core modules redesigned as “tight containers”

only public methods and variables are exposed

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Strict checking of configuration settings

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Anew suite of spatial upscaling algorithms

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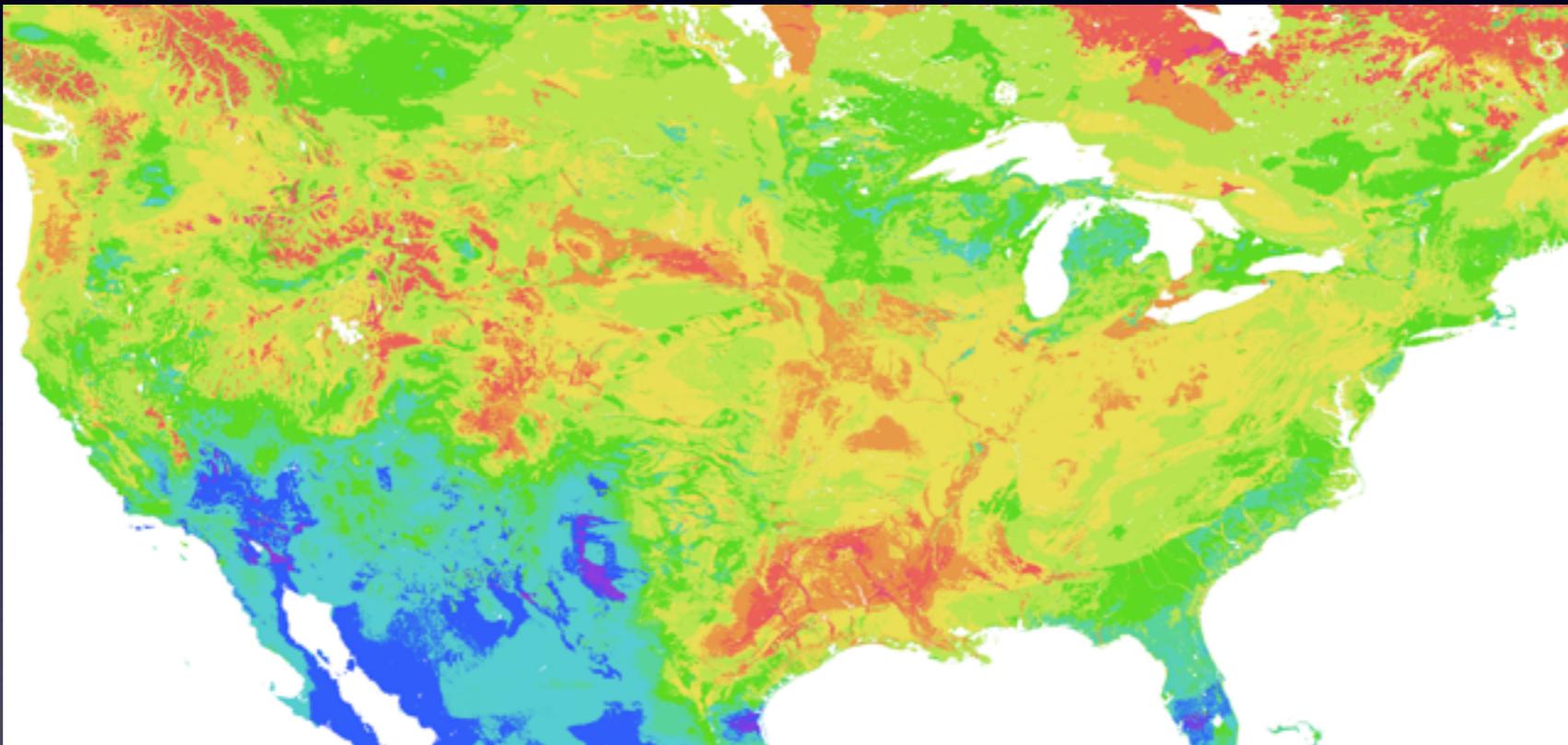
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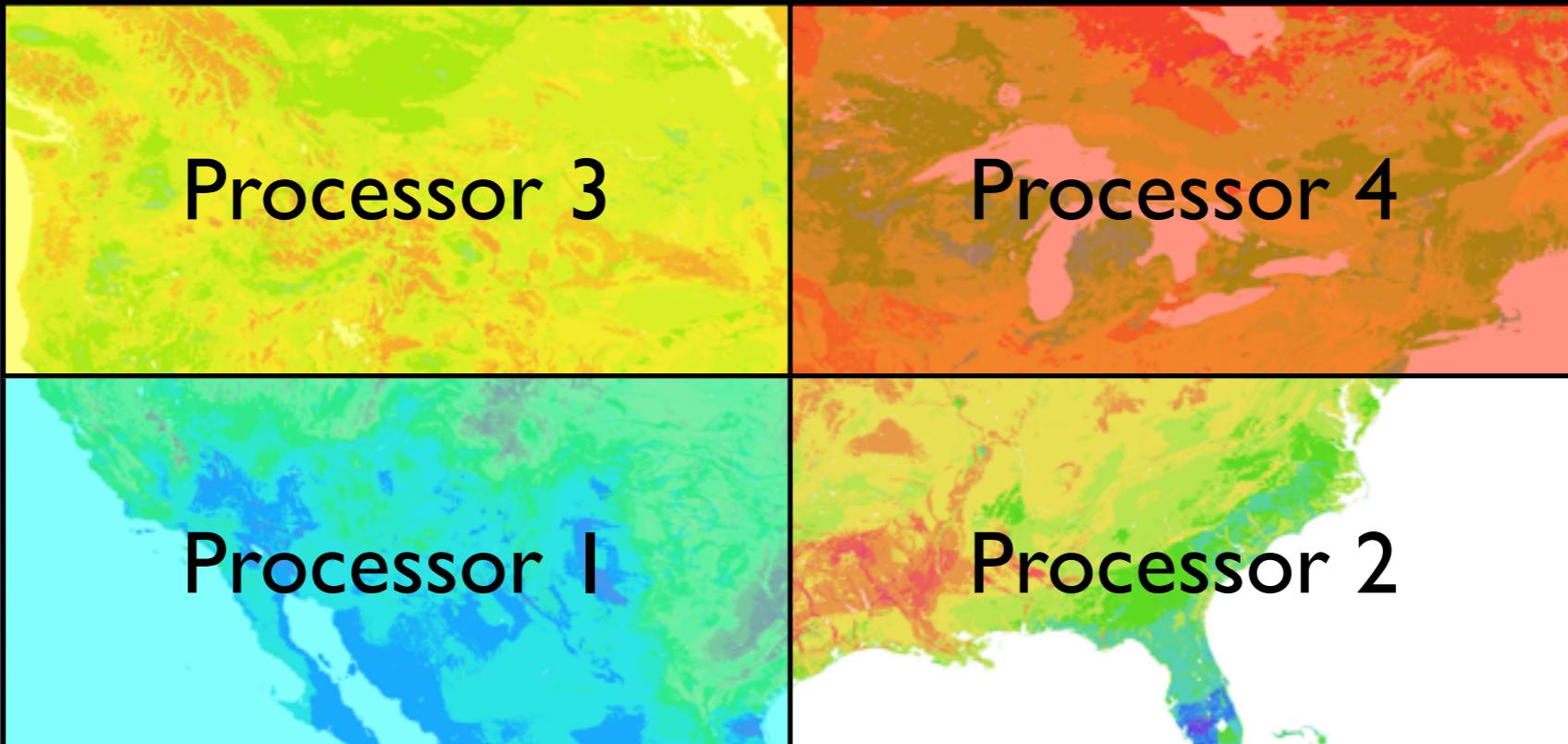
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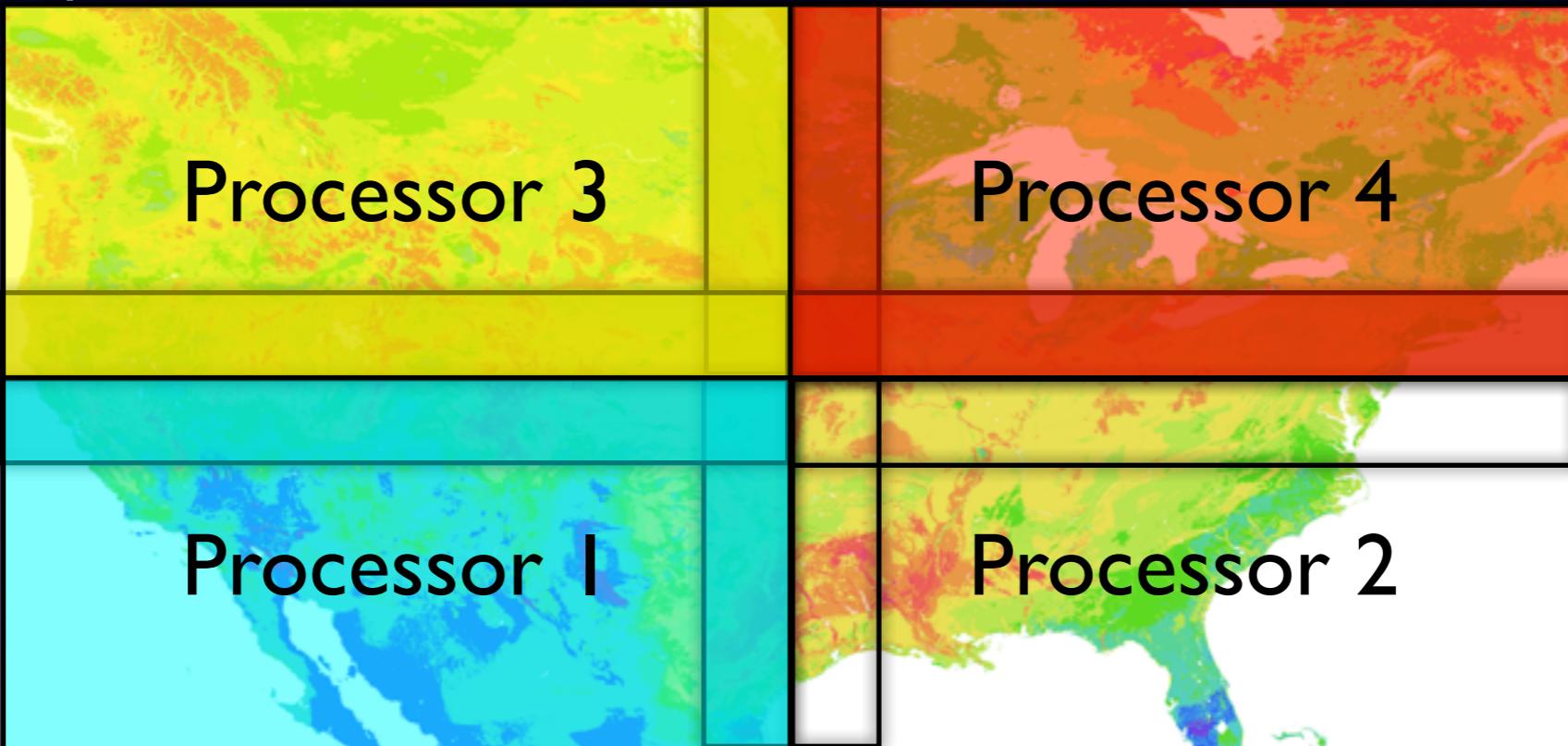
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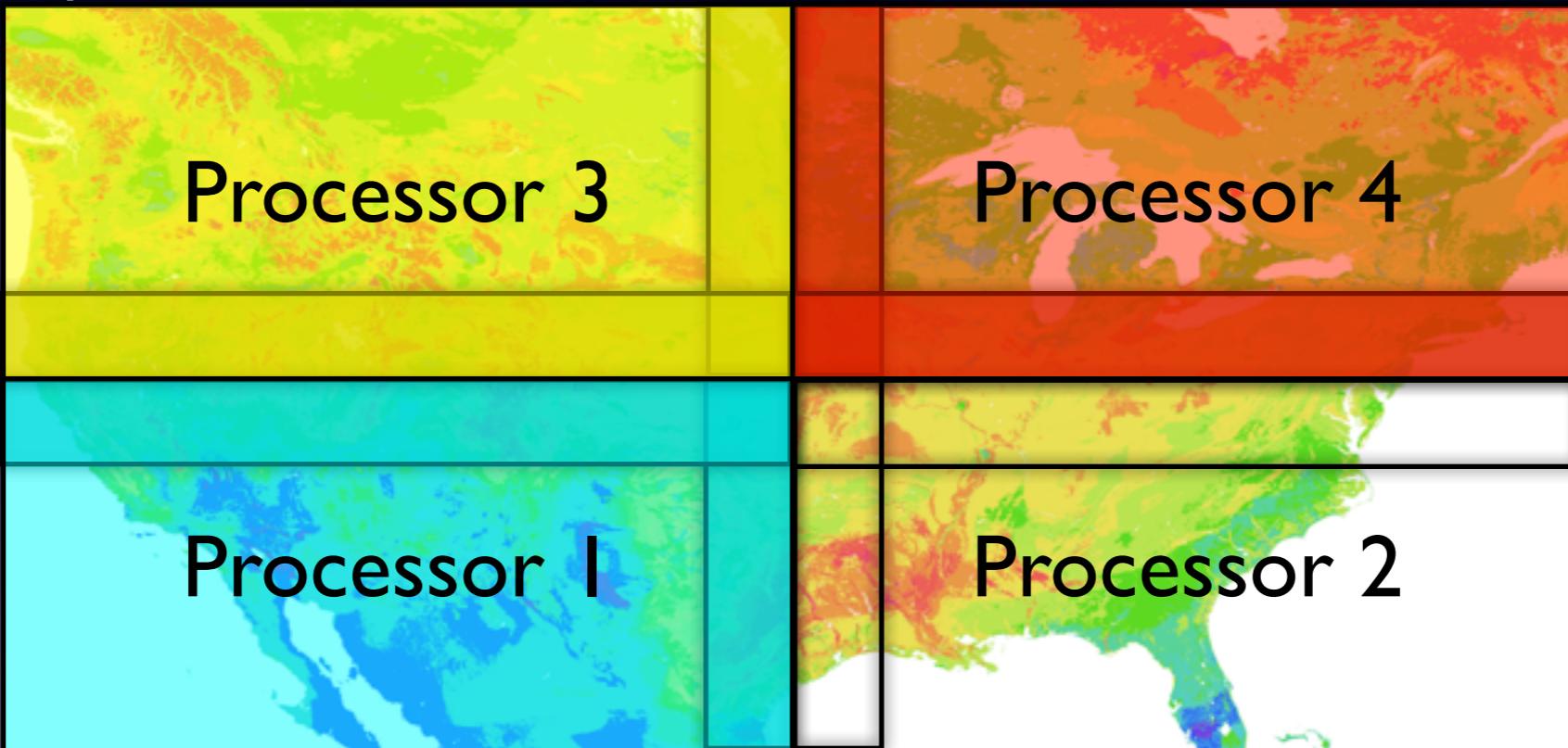
only public methods and variables are exposed

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A new suite of spatial upscaling algorithms

Support for 3d meteorological data

Supports computational halos



Halo size along x: 10  
Halo size along y: 10



# Configurable I/O

Model independent

Binary, GribI, NETCDF

Options for unit conversions

Options for temporal averaging





# Incremental forcing overlays

• Incremental forcing overlays  
• Incremental forcing overlays

Incremental forcing overlays

“Spatial Mosaicing” of different forcings concurrently

## Incremental forcing overlays

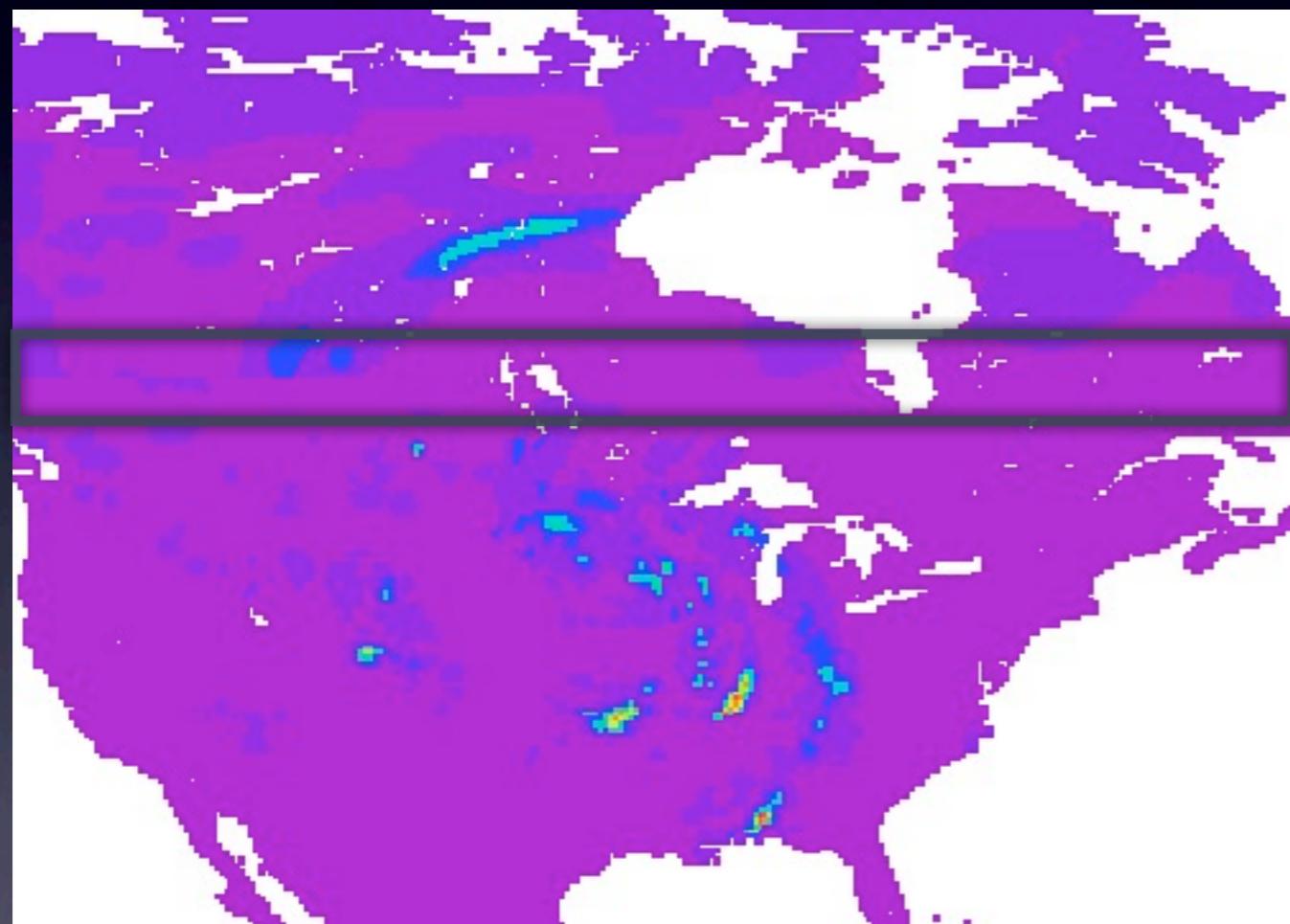
“Spatial Mosaicing” of different forcings concurrently

Multiple, incremental overlays of different supplemental forcings

## Incremental forcing overlays

“Spatial Mosaicing” of different forcings concurrently

Multiple, incremental overlays of different supplemental forcings



NLDAS + GDAS

## Incremental forcing overlays

“Spatial Mosaicing” of different forcings concurrently

Multiple, incremental overlays of different supplemental forcings

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Multiple, incremental overlays of different supplemental forcings

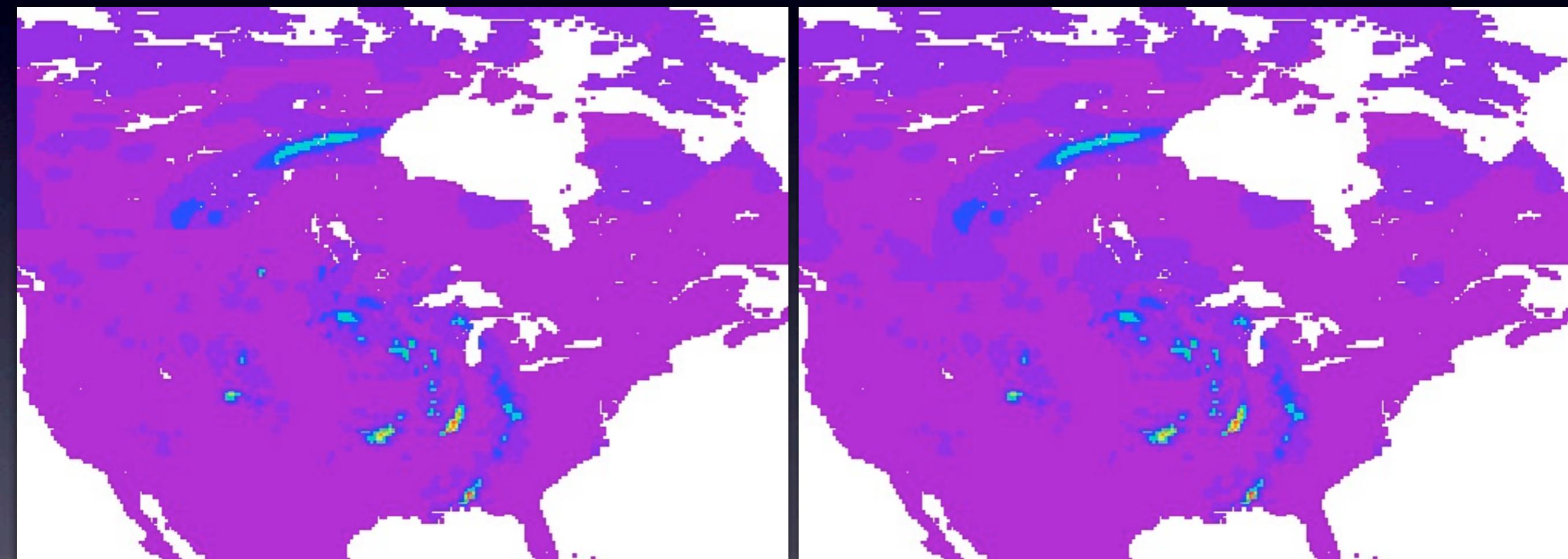
Optional data masks

## Incremental forcing overlays

“Spatial Mosaicing” of different forcings concurrently

Multiple, incremental overlays of different supplemental forcings

Optional data masks



No mask applied

CONUS mask applied

# Incremental forcing overlays

Incremental forcing overlays are a technique used in distributed systems to efficiently update a shared state. The basic idea is to only send the changes (increments) to the relevant nodes, rather than sending the full state from scratch. This can significantly reduce network traffic and improve system performance.

For example, consider a distributed system where multiple nodes are tracking a common counter. If one node increments the counter by 1, instead of sending the entire new state (e.g., 1000) to all other nodes, it only sends the increment (1) and the current state (999). The receiving nodes then update their local copy of the counter.

Incremental forcing overlays are often implemented using a combination of message passing and local state management. When a node receives an increment, it updates its local state and then sends a message to other nodes indicating the change. These nodes then update their own states and propagate the changes further if necessary.

This approach is particularly effective in systems where the state is highly volatile or where nodes have limited bandwidth. It allows for efficient updates and reduces the load on the network, making it a valuable technique for distributed computing environments.

# Incremental forcing overlays



Base forcing source:	1 # GDAS
Number of base forcing variables:	10
Use elevation correction (base forcing):	1 #1-use lapse rate
Spatial interpolation method (base forcing):	1 #1-bilinear
Temporal interpolation method (base forcing):	1 #1-linear
Number of supplemental forcing sources:	3 # 0 or higher
Supplemental forcing sources:	4 2 16 # NLDAS+CMAP+STAGEIV
Number of supplemental forcing variables:	10 1 1
Use elevation correction (supplemental forcing):	0 0 0 #1-use lapse rate
Spatial interpolation method (supplemental forcing):	1 2 2
Temporal interpolation method (supplemental forcing):	1 1 1

Temporal interpolation method (supplemental forcing): 1 1 1  
Spatial interpolation method (supplemental forcing): 1 2 2  
Use elevation correction (supplemental forcing): 0 0 0 #1-use lapse rate

# Incremental forcing overlays



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Number of base forcing variables:	10
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Spatial interpolation method (base forcing):	1 #1-bilinear
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Number of supplemental forcing sources:	3 # 0 or higher
Supplemental forcing sources:	4 2 16 # NLDAS+CMAP+STAGEIV

Number of supplemental forcing sources:  
Supplemental forcing sources:  
Number of base forcing variables:  
Use elevation correction (base forcing):  
Spatial interpolation method (base forcing):  
Temporal interpolation method (base forcing):

#ALMA Name select vlevels units

Tair:	1 1 K	# Near Surface Air Temperature
Qair:	1 1 kg/kg	# Near Surface Specific Humidity
SWdown:	1 1 W/m <sup>2</sup>	# Incident Shortwave Radiation
SWdirect:	0 1 W/m <sup>2</sup>	# Incident Shortwave Radiation
SWdiffuse:	0 1 W/m <sup>2</sup>	# Incident Shortwave Radiation
LWdown:	1 1 W/m <sup>2</sup>	# Incident Longwave Radiation
Wind_E:	1 1 W/m <sup>2</sup>	# Eastward Wind
Wind_N:	1 1 m/s	# Northward Wind
Psurf:	1 1 Pa	# Surface Pressure
Rainf:	1 1 kg/m <sup>2</sup> s	# Rainfall Rate
Snowf:	0 1 kg/m <sup>2</sup> s	# Snowfall Rate
CRainf:	1 1 kg/m <sup>2</sup> s	# Convective Rainfall Rate
Forc_Hgt:	0 1 m	# Height of Forcing Variables
Ch:	0 1 -	# Surface Exchange Coefficient for Heat

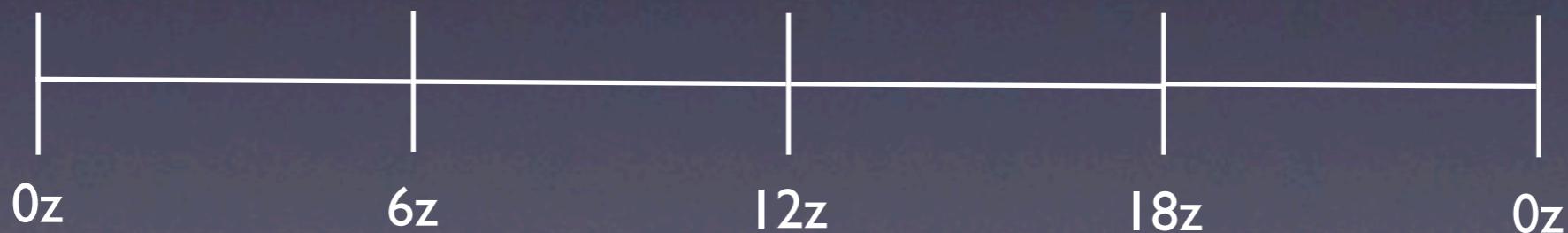


# Incremental data assimilation overlays

Allows concurrent instances of data assimilation

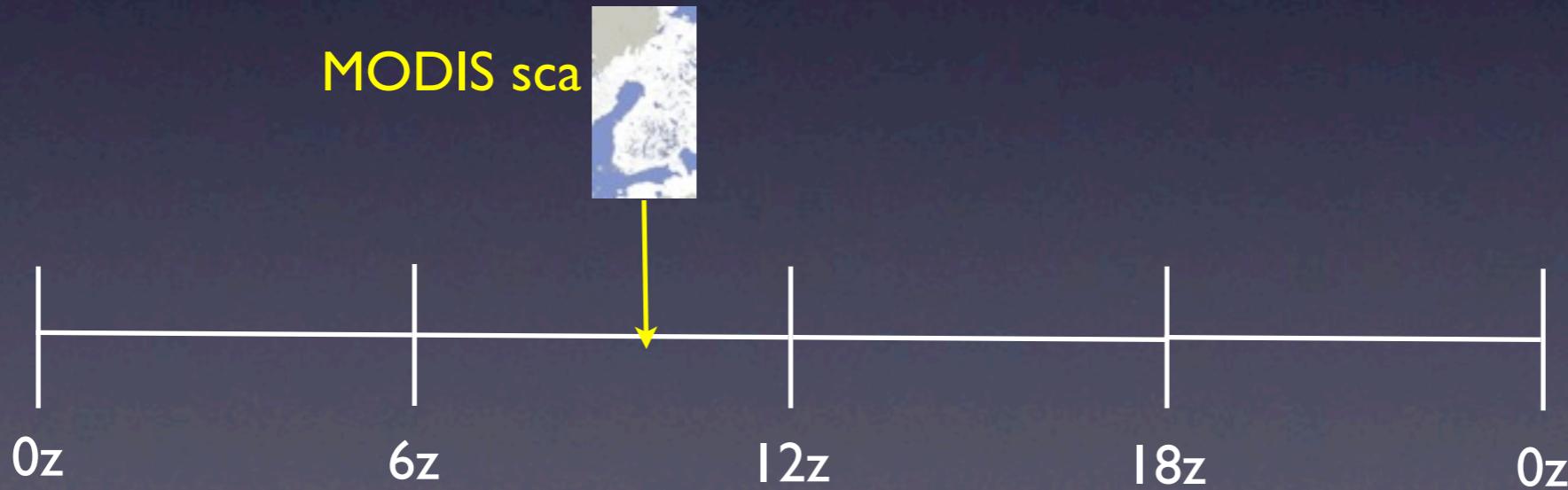
# Incremental data assimilation overlays

Allows concurrent instances of data assimilation



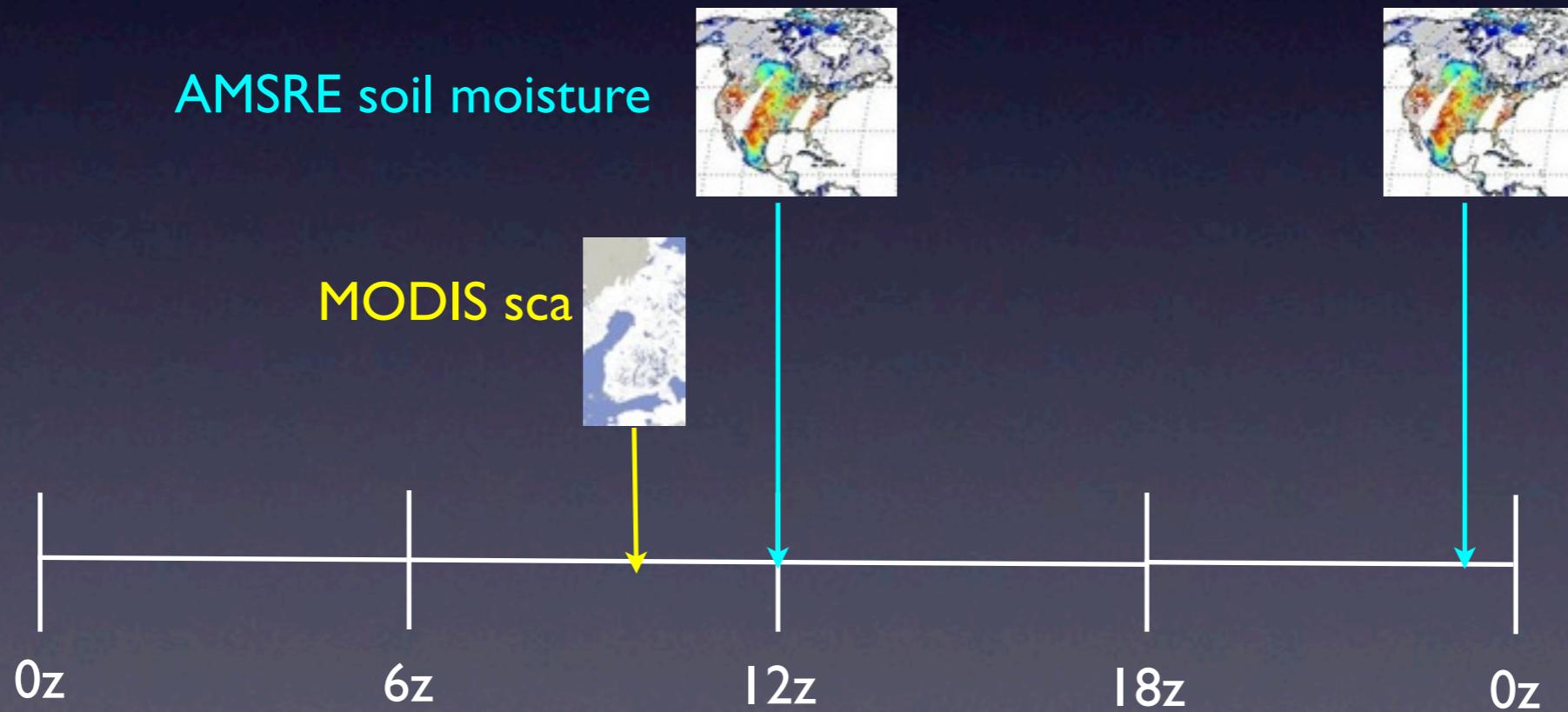
# Incremental data assimilation overlays

Allows concurrent instances of data assimilation



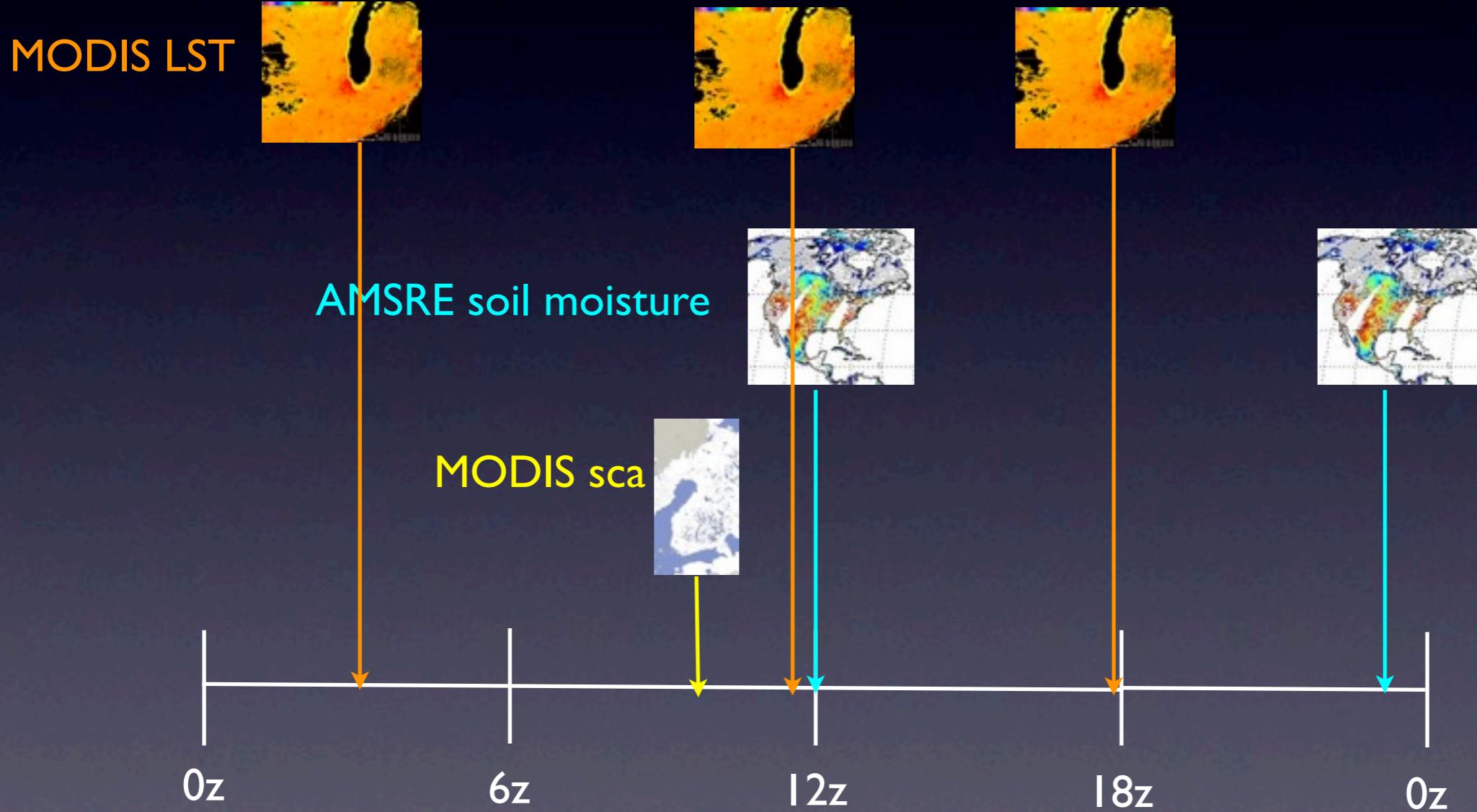
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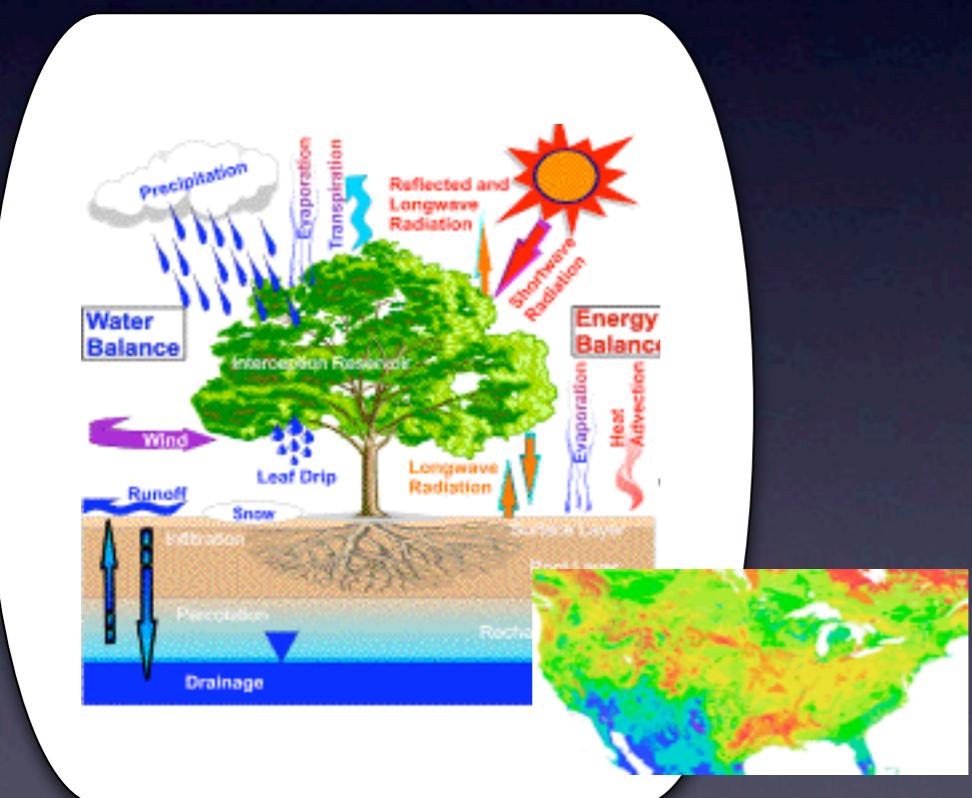


# ESMF-compliant coupling to WRF

ESMF-compliant coupling to WRF

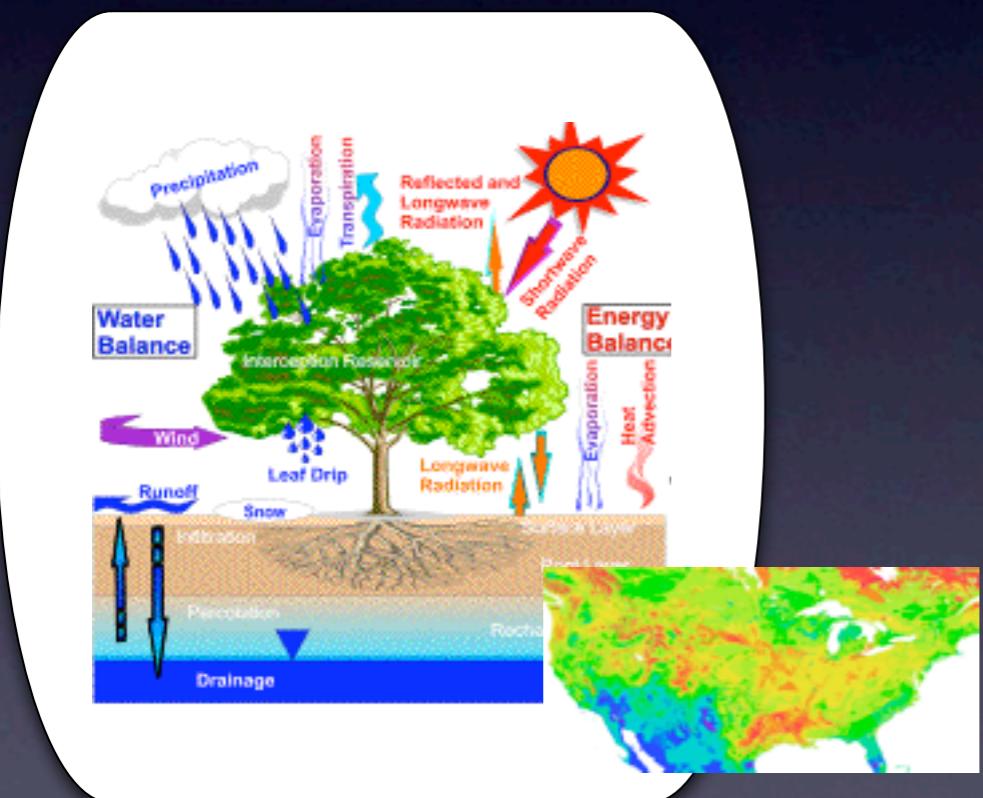
# ESMF-compliant coupling to WRF

LIS

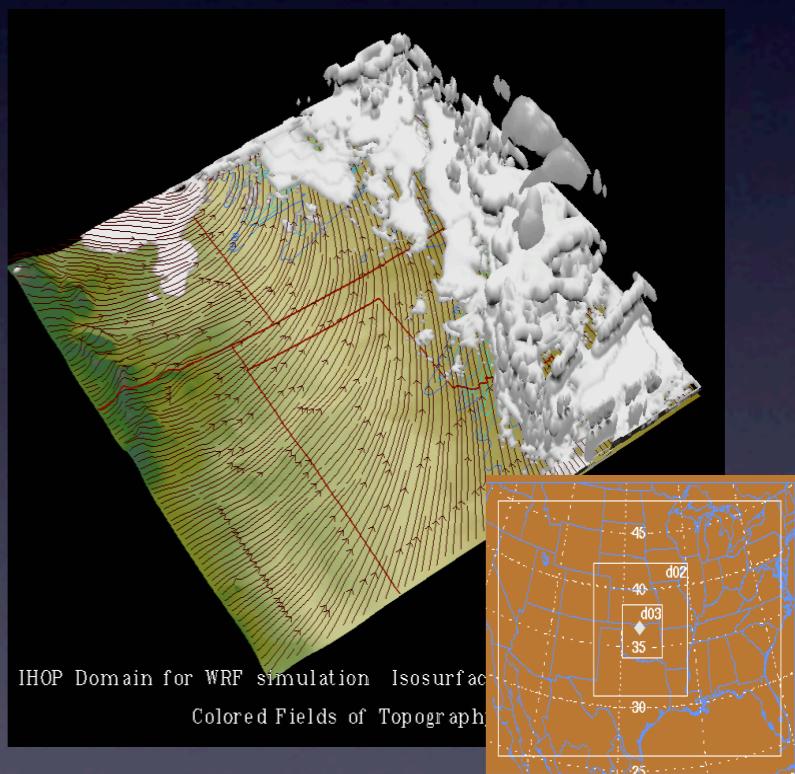


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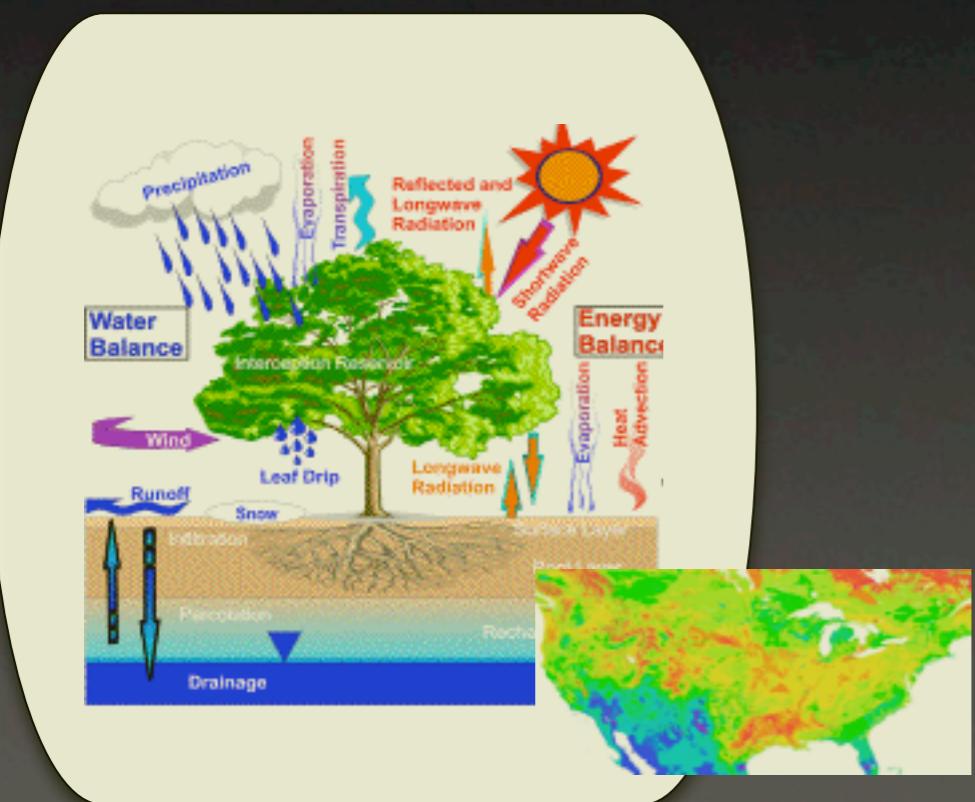


WRF



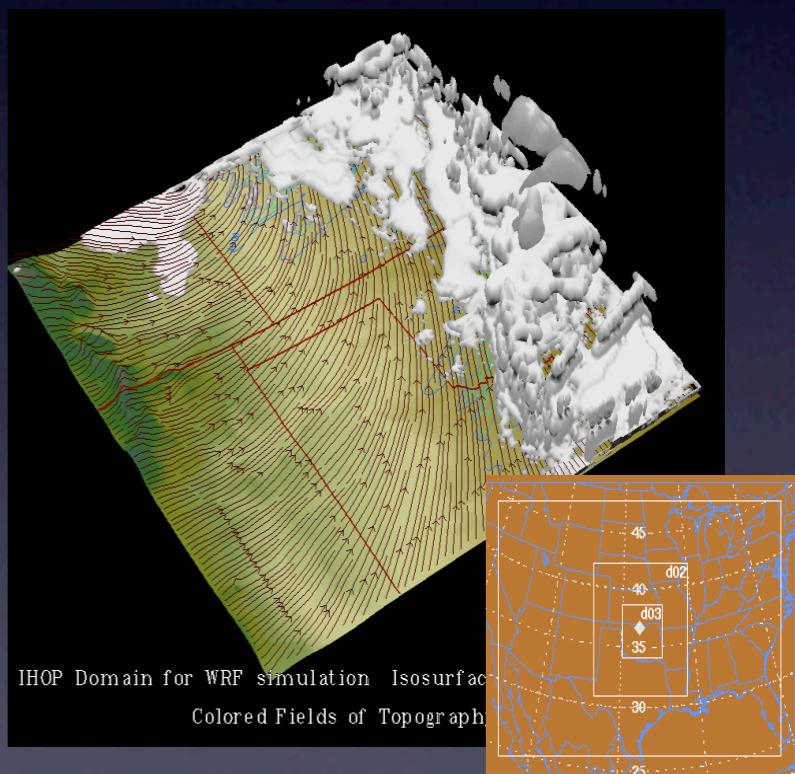
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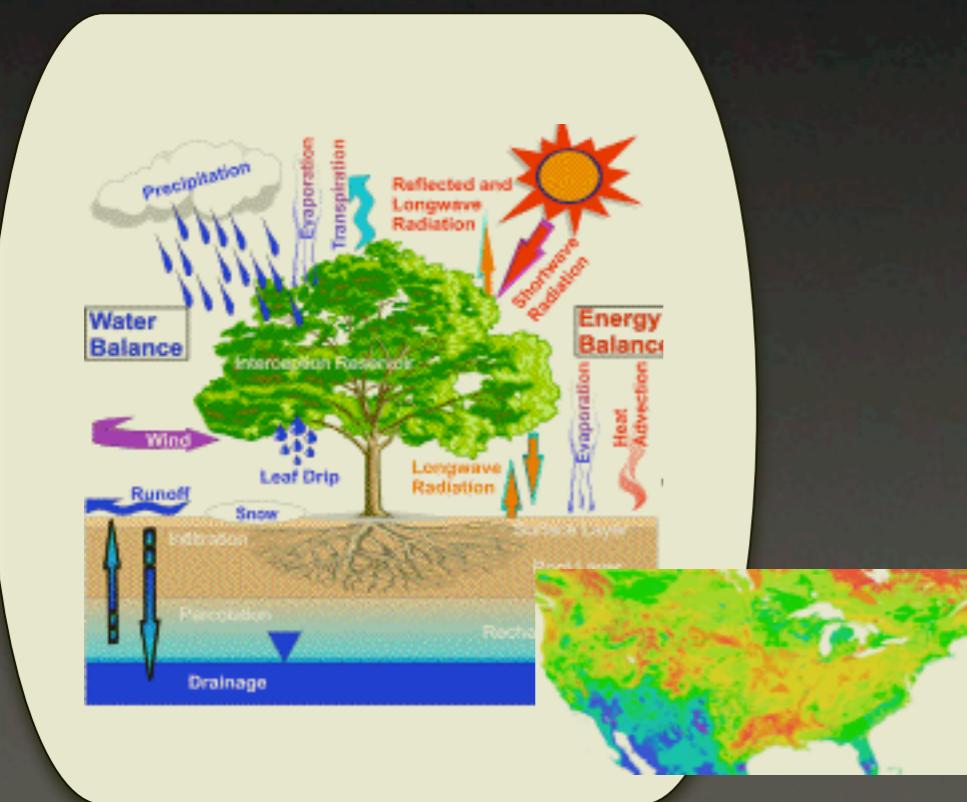
ESMF Gridded Component

WRF



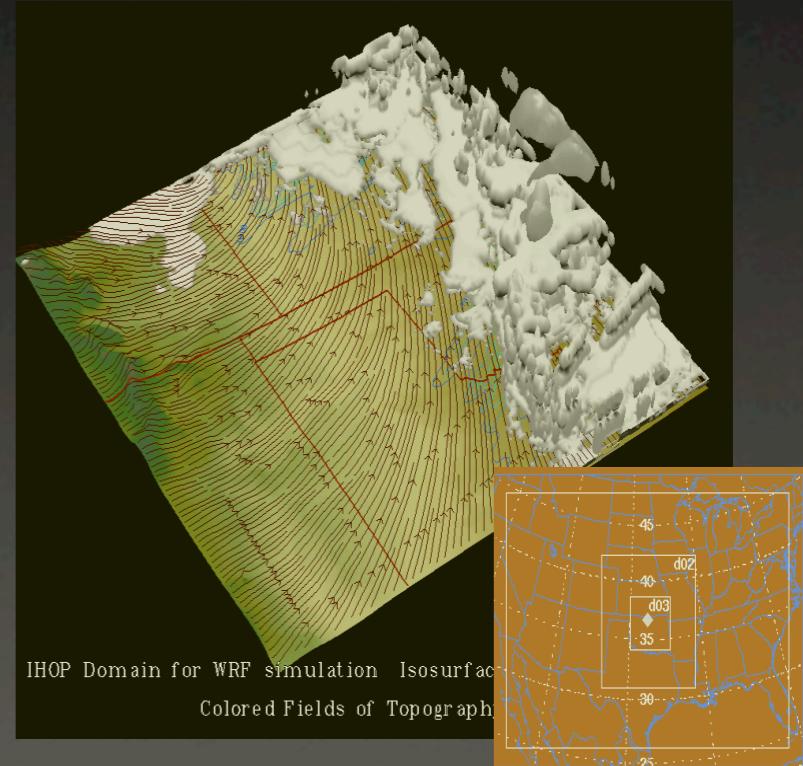
# ESMF-compliant coupling to WRF

LIS



ESMF Gridded Component

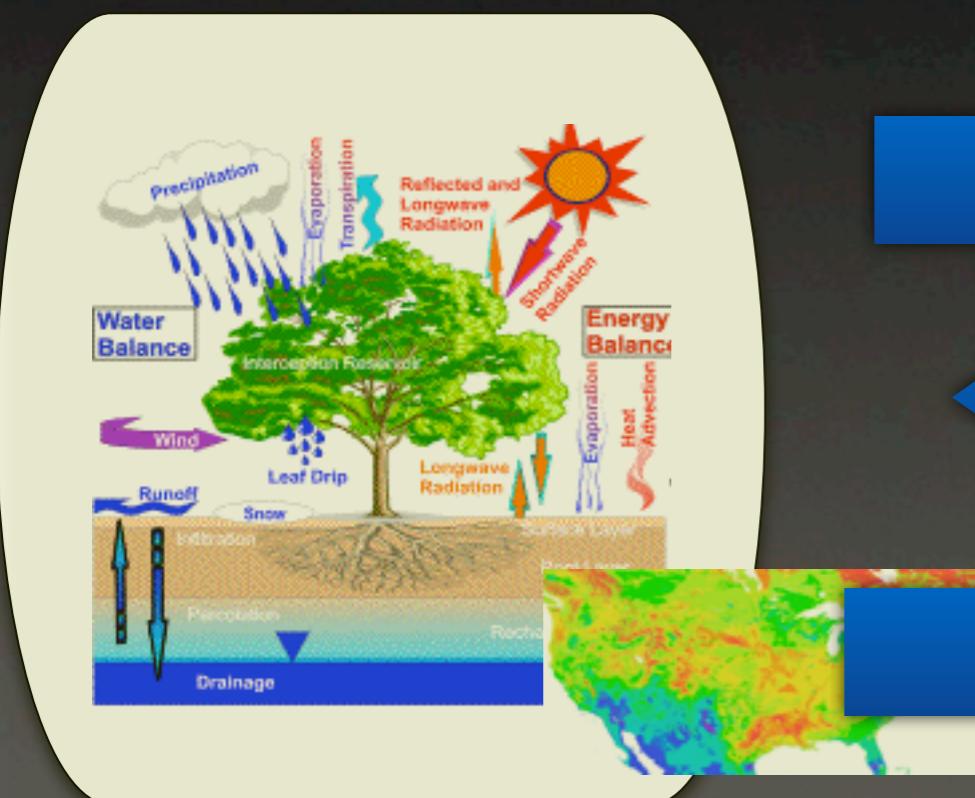
WRF



ESMF Gridded Component

# ESMF-compliant coupling to WRF

LIS

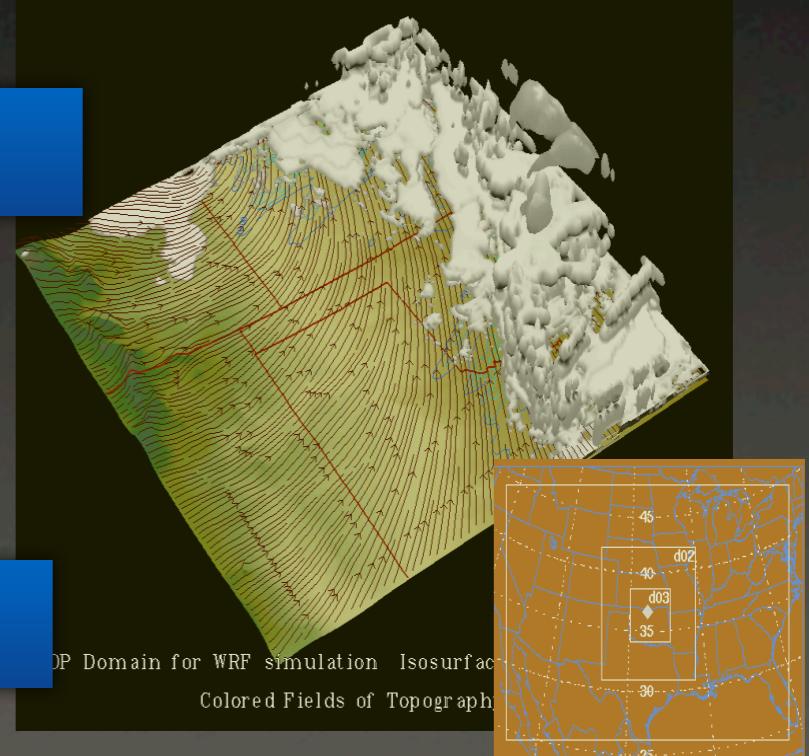


ESMF Gridded Component

ESMF Coupler Component  
LIS to WRF Coupler

ESMF Coupler Component  
WRF to LIS coupler

WRF



ESMF Gridded Component

# Abstractions Layer Enhancements



# Dynamic bias estimation

• **What is dynamic bias estimation?**

• **How does it work?**

• **What are the benefits?**

• **What are the challenges?**

## Dynamic bias estimation

Allows the incorporation of a dynamic bias estimation algorithms

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## Data Assimilation

## Dynamic bias estimation

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Refined interfaces (More QA/QC options, I/O of processed observations)

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## Land Surface Parameters

## Dynamic bias estimation

Allows the incorporation of a dynamic bias estimation algorithms

## Data Assimilation

Refined interfaces (More QA/QC options, I/O of processed observations)

## Land Surface Parameters

Eliminated map projection dependencies



# Radiative Transfer Models

• Radiative transfer models (RTM) are used to predict the spectral flux density at the Earth's surface.

• RTMs solve the radiative transfer equation (RTE) which describes the interaction of radiation with the atmosphere and surface.

• The RTE is a complex equation involving multiple terms representing absorption, emission, and scattering processes.

• RTMs can be solved numerically or analytically, depending on the complexity of the atmospheric and surface properties.

• RTMs are used in various applications such as remote sensing, climate modeling, and atmospheric monitoring.

• RTMs provide a quantitative understanding of the Earth's energy balance and the role of various atmospheric constituents in the radiative transfer process.

• RTMs are essential tools for understanding the Earth's climate system and for developing accurate climate models.

• RTMs have been used to study the impact of greenhouse gases, aerosols, and clouds on the Earth's climate system.

• RTMs are also used to predict the impact of climate change on the Earth's energy balance and the resulting changes in the climate system.

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# Radiative Transfer Models

Allows the incorporation of radiative transfer and forward modeling methods



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Towards a radiance-based data assimilation system

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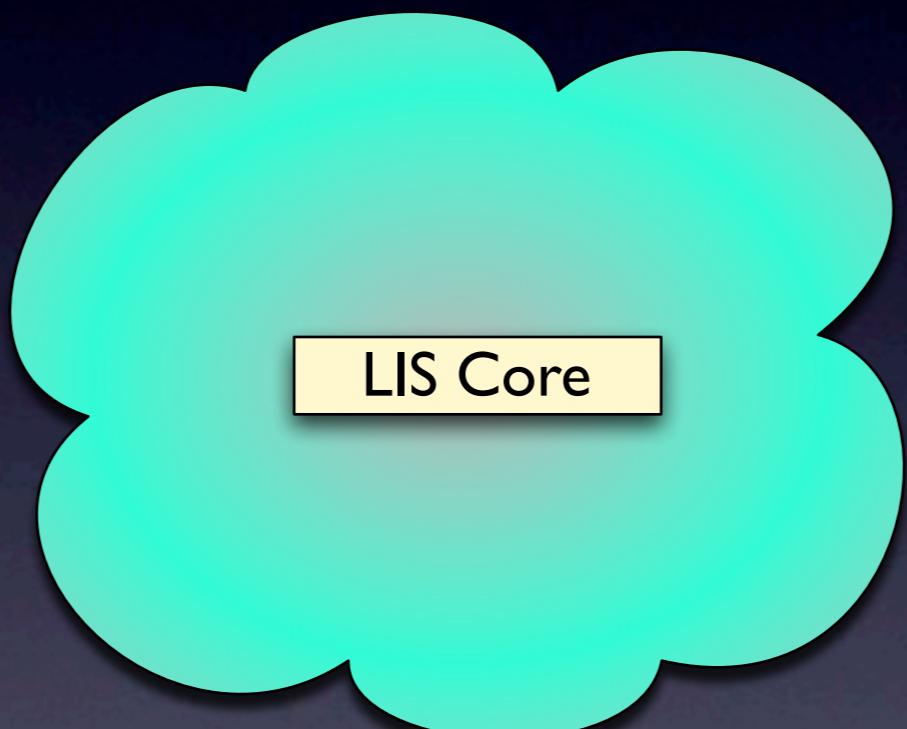
Allows the incorporation of radiative transfer and forward modeling methods

Towards a radiance-based data assimilation system

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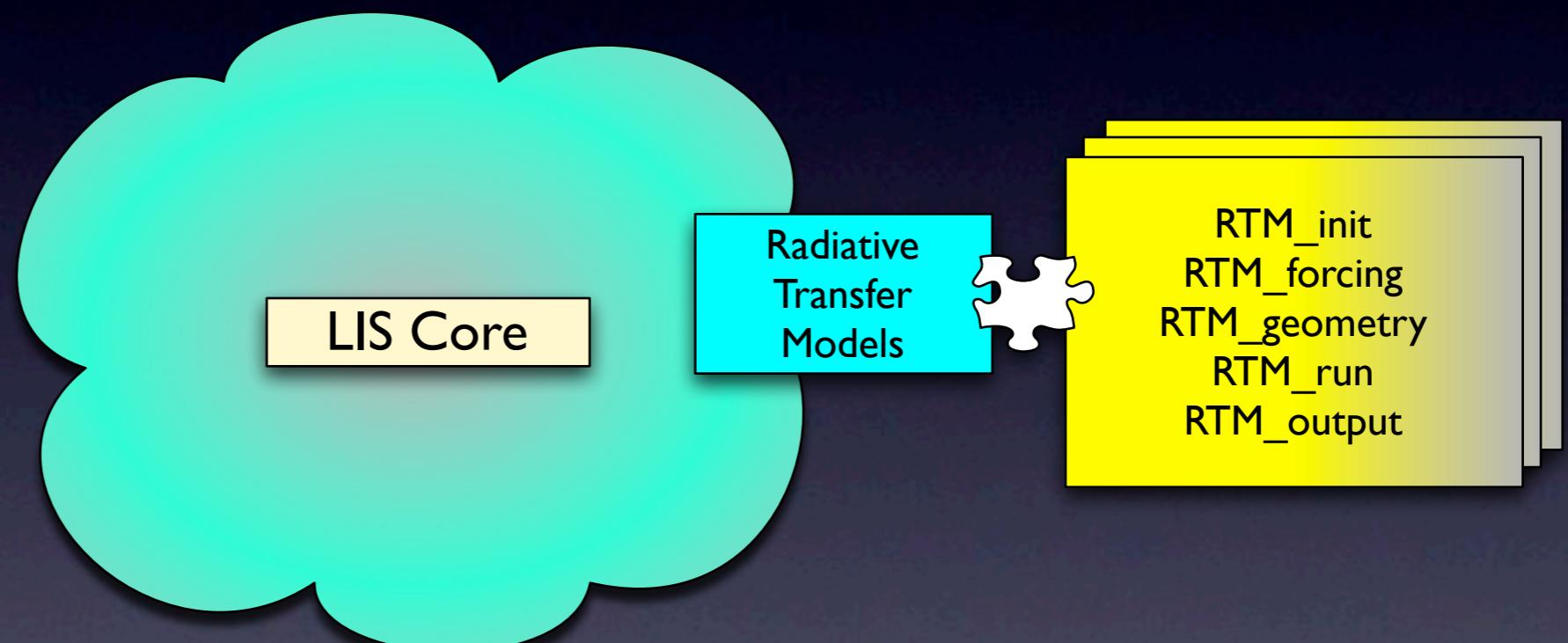
Towards a radiance-based data assimilation system



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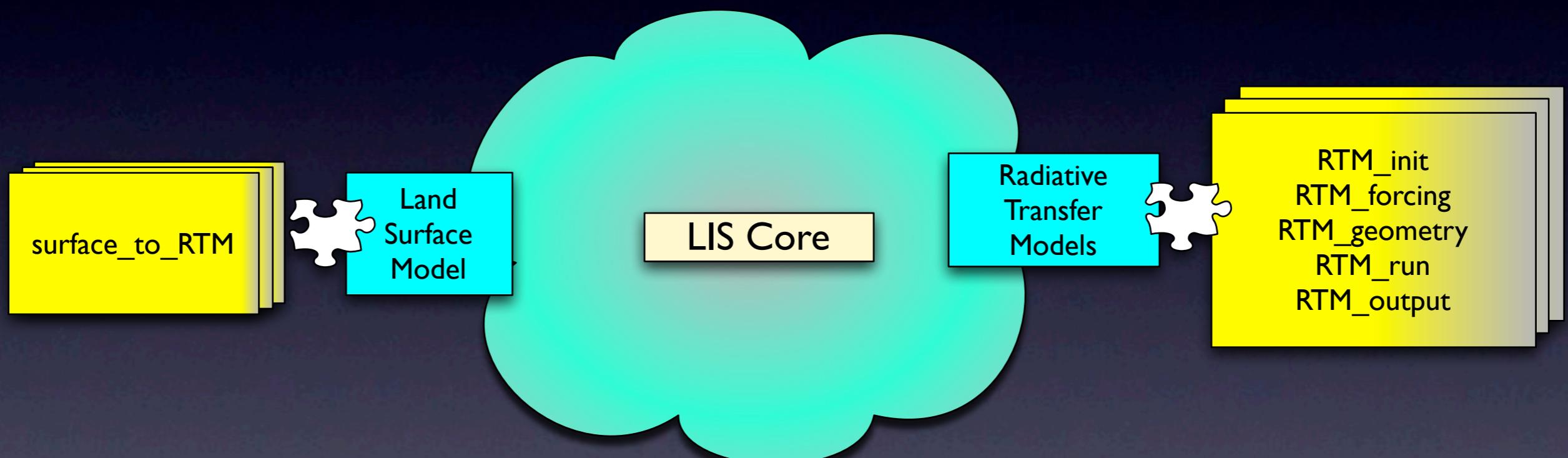
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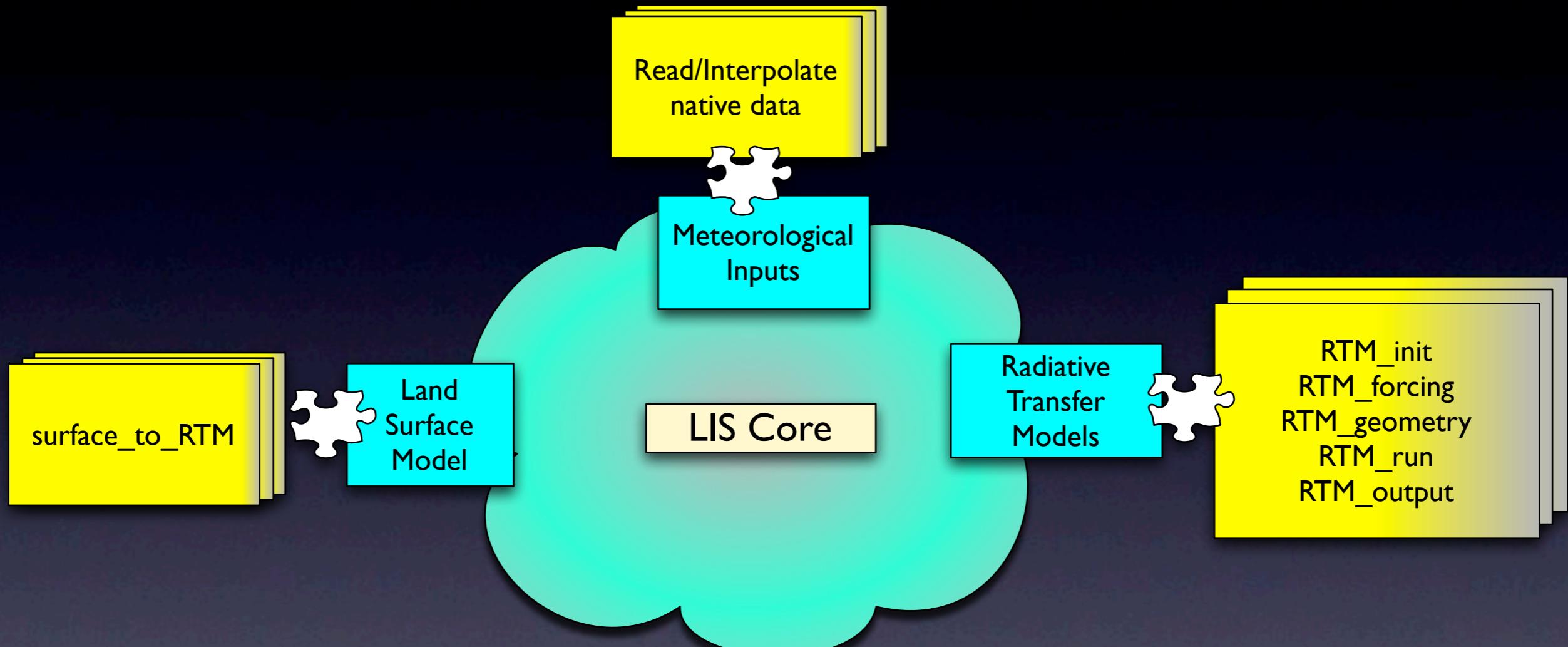
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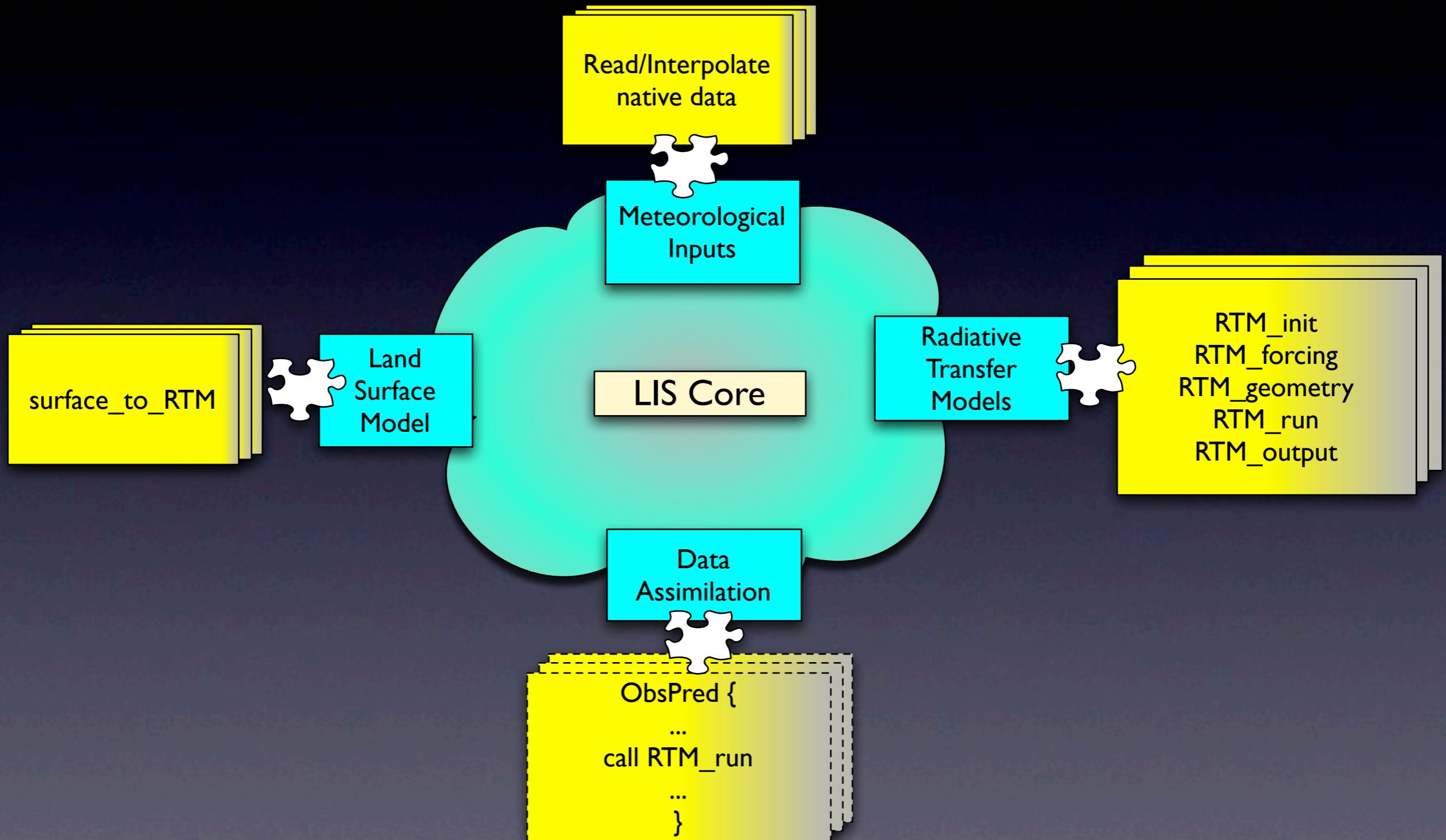
Towards a radiance-based data assimilation system



# Radiative Transfer Models

Allows the incorporation of radiative transfer and forward modeling methods

Towards a radiance-based data assimilation system





# Optimization



# Optimization

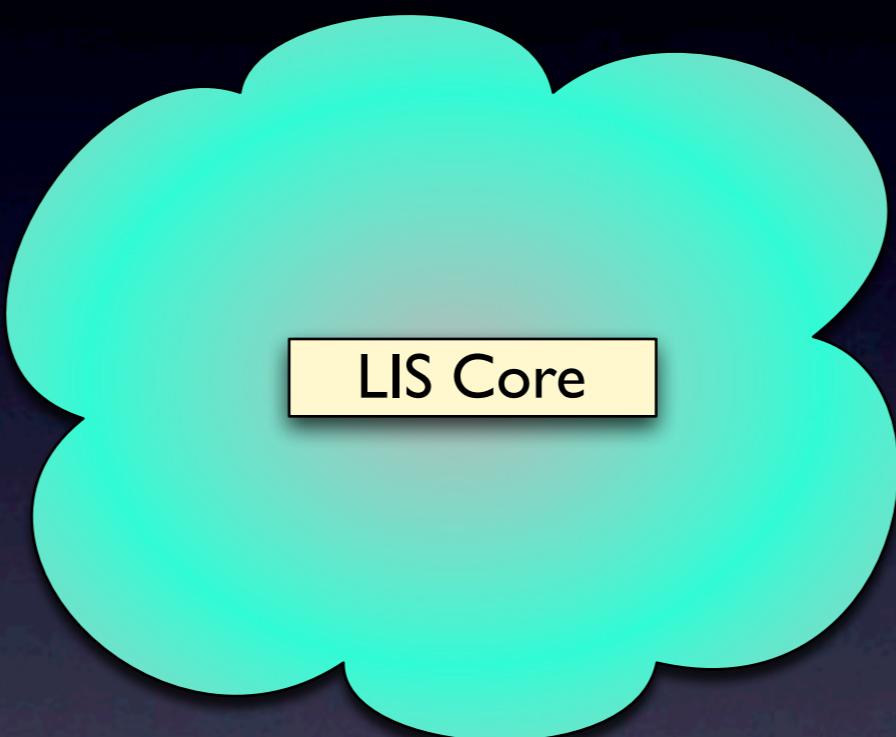
Allows the incorporation of optimization algorithms

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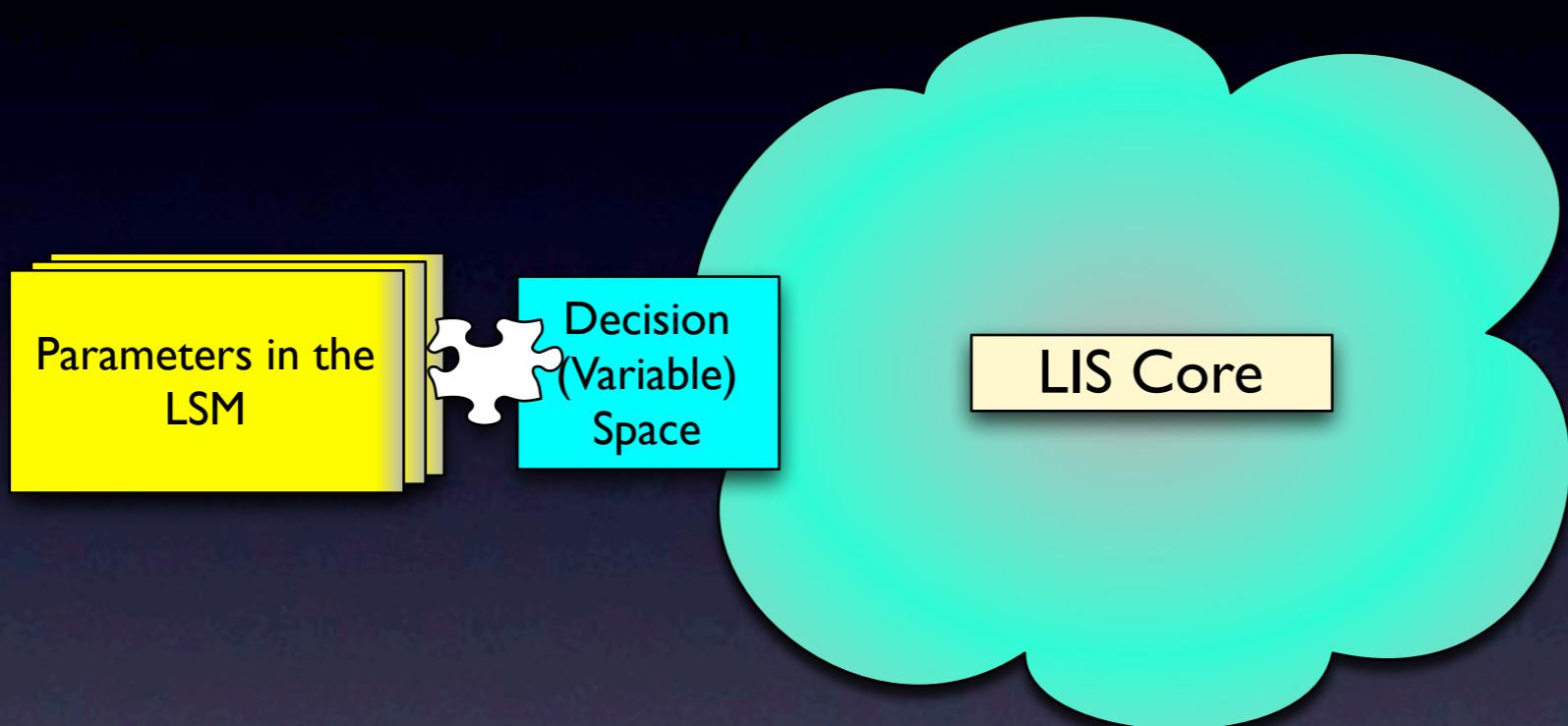
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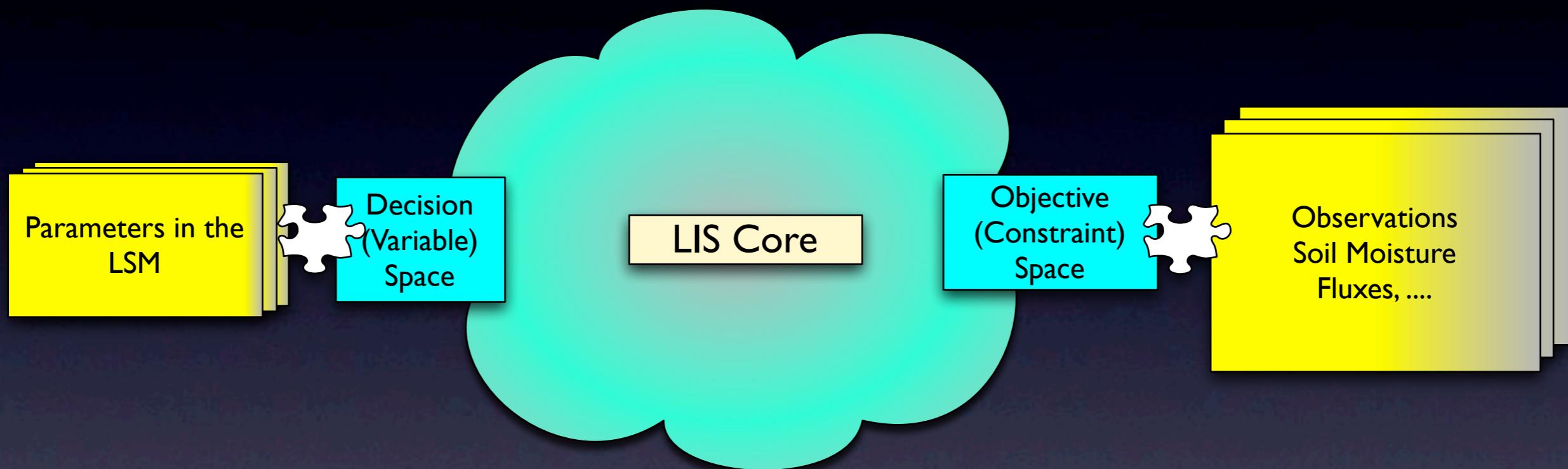
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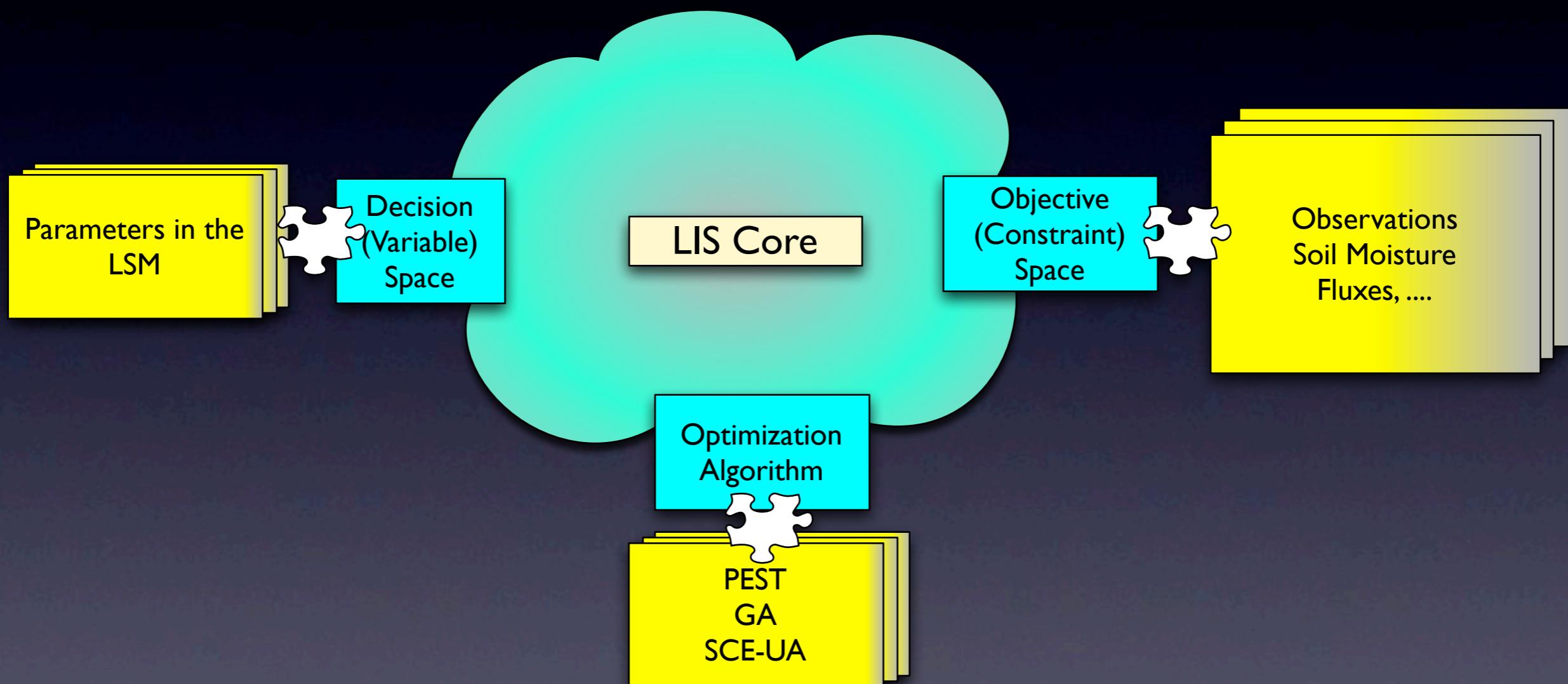
# Optimization

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# Model Layer Additions





**LSMs:** Noah 3.1 (supports concurrent use of multiple Noah versions), TESSEL, PLACE, CLM3.5

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**Running Mode:** RTM forward mode, Parameter estimation mode

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# Useful (unsupported!) utilities



**Ensemble restart generator:** Generates a restart file for an ensemble run from a single ensemble member restart file

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**GrADS control file generator:** Generates a GrADS control file for a LIS simulation

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More to come.... Contributions encouraged....

# Caveats

- No “public” release yet
- Considerable changes to LIS configuration
- Documentation and Testcases are still being updated